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1. Introduction

The current discussion on the importance of Information and Communication Technologies (ICTs) for cities and regions is not something new in the literature. At the beginning of the 20th century, Britain's hegemony in the world economy was reflected in London's dominance in the global telegraph network and in its role (inter)connecting London with North America and the outskirts of the British Empire (Hugill, 1999). Some thirty years ago, Toffler was talking about the emergence of tele-cottages (1980), Hepworth in the late 1980s was analyzing the Geography of the Information Economy, and later on, heated debates around the 'death of cities' (Gilder, 1995; Drucker, 1998; Kolko, 1999), the Internet's anti-spatial nature (Mitchell, 1995) and the 'death of distance' (Cairncross, 2001) occurred more frequently in the relevant literature. A common denominator in this stream of studies was the lack of empirical analysis in support of the policy-related discussion about the pervasive character of ICTs, at least from a spatial perspective.

Indeed, the empirical geographic analysis of ICTs attracted limited interest from geographers, planners and spatial scientists in general. The intangible and technical nature of ICTs is the main reason why this subject stayed out of mainstream research. Economic and urban geographers as well as spatial scientists usually deal with tangible objects, contrary to the elusive nature of ICTs (Bakis, 1981; Hepworth, 1989; Kellerman, 1993). Additionally, the digital infrastructure, just like any other network infrastructure, is fairly invisible when it works accurately and only becomes visible when it stops working (Star, 1999). Moreover, the complex technical structure of the digital infrastructure deteriorates the spatial scientists' ability to fully comprehend the topology, structure and design principles of such networks (Kellerman, 1993).

On top of the above constraints, the lack of empirical analysis – which prevented researchers from mapping and fully understanding the digital layer which supports the function of cities and regions – may be attributed to the lack of relevant data about the digital infrastructure (supply side) and the use of this infrastructure (demand side). Firstly, because of the private and fragmented nature of digital infrastructure and the derived services, there is no central agency with responsibility for collecting and retrieving data, such as digital connectivity and capacity of cities or telecommunication and Internet Protocol (IP) traffic flows (Kende, 2000). Despite the fact that companies which own and manage digital infrastructures, such as Internet Service Providers (ISPs), collect both demand and supply side data for calibrating their networks, such data is not published for competition reasons, a trend which intensified by the private nature of these companies (Graham & Marvin, 1996). However, this is not new. Batty in the early 1990s argued that there is no interest in the impact of information flows on cities (Batty, 1990), Moss in the late 1980s characterized telecommunications infrastructural networks as a mystery to most cities (1987), and Graham and Marvin (1996) admitted that many city planners were not aware of the telecommunications infrastructure supply in their cities.

Nonetheless, we are currently entering in a new era which is characterized by the abundance of digitally collected bottom-up data. Examples of such sources include mobile phone and landline providers for telecommunication patterns and *real time* urban analysis, ISPs for IP communications and Internet infrastructure, transport operators for commuting patterns based on e-ticketing facilities, Web 2.0, participatory Geographic Information Systems (GIS), and virtual social networks etc. The availability of such exciting data sources provides new opportunities and challenges for urban and regional analysis. On the one hand, we are able not only to map the underpinning layers of the digital economy, but also to better understand the way cities and regions function. On the other hand, the analytical tools that spatial sciences traditionally use need to be enriched with methods and concepts developed in other disciplines such as *complexity* and *network science*. The use of toolboxes from such disciplines in combination with new bottom up, digitally collected data for entire populations will enable spatial scientists to better understand and model the dynamics of the digital economy and its underpinning layers and also to evaluate the efficiency of urban and regional policies.

In total, spatial scientists cannot afford to ignore the digital revolution and the intensification of the digital economy for two reasons. Firstly, new digital phenomena, such as the Internet, have spatial reflections that need to be approached from a geographic perspective. Secondly, the profusion of new bottom-up data derived from digital sources enables the research community to study and quantify traditional geographic questions from a new perspective achieving greater spatio-temporal resolution. In addition, it needs to be noted here that despite the still evident *digital divide* in various aspects of the digital economy between the developed and developing world, the wide penetration of mobile technologies such as (smart) mobile phones, smoothens such divides and at the same time can potentially provide digital bottom-up data for places that even traditional secondary sources are in scarcity or even not trust-worthy. From a policy perspective, such analytical efforts will enable researchers to inform policy makers and to include digital themes in the local policy agenda.

The above two elements are the main focus of this chapter. After providing a background of the digital revolution, this chapter will continue with empirical examples of digital phenomena with spatial reference and traditional geographic phenomena which can be approached with digital data. This chapter ends with some concluding results summarizing the 'digital' challenges and opportunities for urban and regional scientists.

2. The digital revolution in social science literature

This section provides the necessary background on the discussion around the digital revolution from a social science perspective. Apart from critically presenting the notion of the digital economy, this section will briefly discuss Castells' seminal work on the space of flows. The latter will enable us to better understand how the digital revolution affects cities and urban networks.

2.1 The digital economy

The most recent attempt to conceptualize the current economic system is summarized under the term *digital economy*. The latter is usually related with economic transactions taking place in the Internet (Atkinson & McKay, 2007). However this is only part of what the digital economy really is. Atkinson and McKay (ibid, p. 7) define it as follows:

> "The digital economy represents the pervasive use of IT (hardware, software, applications and telecommunications) in all aspects of the economy, including internal operations of organizations (business, government and non-profit); transactions between organizations; and transactions between individuals, acting both as consumers and citizens, and organizations. Just as 100 years ago the development of cheap, hardened steel enabled a host of tools to be made that drove economic growth, today information technology enables the creation of a host of tools to create, manipulate, organize, transmit, store and act on information in digital form in new ways and through new organizational forms" (Cohen et al., 2001).

The main characteristic of the digital economy is the pervasive character of ICTs in all sectors of the economy. This is the distinctive element in comparison to other conceptual vehicles used to understand the post-industrial economy such as the *information* economy and the *knowledge economy*. The former is linked with specific sectors of the economy. For instance, Porrat (1977) identified the *informational worker* and he developed an inventory with 422 informational occupations based on the US Census of Population workforce classification. Additionally, concepts such as *quaternary employment*, which refers to services "closely related to the production, processing and distribution of information" (Gottmann, 1983, p. 66) and the *informational sector* were introduced to support the concept of the information economy (Hepworth, 1989).

The *knowledge economy*, which is a fairly recent concept, is more widely framed: no explicit knowledge sector was identified and the definition of knowledge-based occupations was also extended out of the service sector (Neef, 1998). Knowledge is directly linked to information because "knowledge is more than information as information is more than simply data" (Malecki & Moriset, 2008, p. 29). The relation between these notions is hierarchical: one place higher in the hierarchy is related with a higher level of sophistication, codification and therefore value. In the same way, Nijkamp and Jonkhoff (2001, p. 2) identified knowledge as the "accumulated stock of information based on synergies" contrary to these "structured flows of data", which form information. Because of the above, knowledge, as a commercialized entity, has become one of the factors of production, in advance of capital and labour (Drucker, 1998). According to OECD's (1996, p. 7) definition, knowledge based economies are economies "which are directly based on the production, distribution and use of knowledge and information".

However, such a sectoral definition does not exist for the digital economy. Indeed, the latter refers to the impacts that economy in total can enjoy – mostly through productivity gains – because of the extensive use of ICTs in all aspects of the economy (Atkinson & McKay, 2007). In simple words, computers, telecommunications and their combined function known as *infocommunications,* support downstream industries in all sectors of the economy (Malecki & Moriset, 2008). This process results in productivity effects, which can be distinguished in *capital deepening* and *total factor productivity* gains (Atkinson & McKay, 2007). While the former refers to the fact that increased capital results in increased labour productivity, the latter refers to productivity increases when the same amount of capital is used more efficiently. Additionally, OECD (2003) suggests a third path for expanding productivity gains: the productivity acceleration in the ICTs-producing sector and the expansion of the ICTs-producing sector in the economy. In a nutshell, such productivity gains can significantly affect economic growth.

To sum up, a common characteristic of the above analyzed concepts is that they span across the different sectors of the economy and are not limited to the Internet-based new economy (Malecki & Moriset, 2008). As explained above, the challenges and changes the post-industrial economic system underwent and is still experiencing are wider than this. Additionally, despite the different starting points, there are overlaps between the three different concepts discussed above, since they approach the same phenomenon from different perspectives: the new techno-economic paradigm of the post-industrial economy. While the first two approaches mostly focus on the soft factors of this paradigm (i.e. information, knowledge and the learning process), the digital economy framework mostly emphasizes the hard factors (i.e. ICTs). However, all the three theoretical concepts agree on the central role of ICTs in this new paradigm. This led Antonelli (2003, p. 197) to characterize advanced telecommunications services as the backbone of the new economy.

2.2 The space of flows

From an urban perspective, both the digital revolution and the underlying new techno-economic paradigm are associated with creating drastic social changes. The starting point for understanding these changes is the seminal work of Castells on the *space of flows*. In his work about the *network society* (Castells, 1996), he illustrated the emergence of a new spatial form due to the structural transformation that our society is undergoing because of the extensive use of ICTs. He identified this new spatial form as the space of flows and he defined it as the "managerial organization of time-sharing social practices that work through flows" (ibid, p. 442). Such flows are the outcome of the digitally enhanced interaction between remote social actors. To better describe this new spatial form, Castells decomposed the space of flows to a three layer system. The first layer can be parallelized with what Batty (1997) identified as the *cyberplace* (Malecki, 2002) and consists of the technical network infrastructure, upon which the flows of Castells' network society are transported. This infrastructural layer of communications "defines the new space, very much like railways defined *economic regions* and *national markets* in the industrial economy" (Castells, 1996, p. 433).

The second layer refers to the nodes and the hubs of the space of flows. These are the real places with “well-defined social, cultural, physical, and functional characteristics” (ibid, 443). These places – cities in reality – are interlinked through the first – infrastructural – layer of the space of flows. An example of this layer is the global financial network, which consists of specific places around the world where the global financial markets are located. Lastly, the third layer of the space of flows refers to “the dominant managerial elites” and analyzes the spatial organization of these privileged social groups, which are increasingly located in isolated communities, but at the same time in highly connected places (ibid, 433).

While Castells highlighted the importance of the first layer as an underpinning layer of the space of flows, not surprising his analysis was mostly focused on the upper layers due to the data constraints discussed above.

2.3 Digital revolution and cities

This new spatial configuration has affected cities dramatically. The development of digital technology has prompted many questions on its space-time trajectories and its socio-economic and spatial implications. It is often argued that the digital world is not a result of technological determinism, but to a large extent a technological response to social and economic needs and challenges. This holds true not only at macro levels (e.g. nations), but also at local and regional levels.

The physical world of urban (infra)structure and transport, and the virtual world of urban communications and interactions, are often regarded as two disjointed domains. Structuralist explanations for the spatial constellations of cities – such as Von Thünen’s concentric model or Burgess’ ecological lay-out of cities – did not take into account the close interwovenness between the real and the cognitive dimensions of city life. In the past years, the emergence of ICTs has prompted an overwhelming interest in the cyber constituents of modern cities (see e.g. Graham & Marvin, 1996; Cohen et al., 2002; Cohen-Blankshtain & Nijkamp, 2004; Cohen-Blankshtain et al., 2004; Melody, 1996). It turns out that ICTs do not only generate benefits of all kinds for the urban economy, but also act as a driver that shapes novel urban structures and influences its metabolism.

In addition, it is safe nowadays to (re)confirm that geography still matters! Cities are strategic nodal centers in a complex spatial network. The linkage structure in such networks may be both physical and virtual. Despite the ‘death of cities’ hypothesis, cities have turned out to strengthen their position in a digital world. In most cases, ICT technology has not led to a flat landscape (Friedman, 2005), but even more to a ‘spiky’ landscape (Florida, 2005; Rodríguez-Pose & Crescenzi, 2008). Geography still matters apparently, while ICTs add only another complicating factor for the locational analysis of people and firms.

Rising agglomeration benefits prompt firms to seek a central location, but the high land rents in cities may stimulate firms to choose more peripheral and low-cost areas, while still having a high –local and global– connectivity through ICT use.

Clearly, distance may lose part of its importance as a major impediment, but agglomeration benefits may grow even faster. Under such circumstances, ICTs may help to reduce the cost of physical movement and hence stimulate more real transport flows.

At a different scale, it is noteworthy that the virtual world has opened up a complex ramification of global linkages between cities, with a surprising variety in intensity and complexity, which calls for novel quantitative geographic network analysis. Before moving to such empirical examples, these global inter-urban links can be approached through the lens of the space of flows. According to Castells (1996, p. 417):

> "the global city is not a place but a process. A process by which centers of production and consumption of advanced services, and their ancillary local societies, are connected in a global network, while simultaneously downplaying the linkages with their hinterlands, on the basis of informational flows".

ICTs, just like transportation, support this process. ICTs are friction-reducing technologies, because they reduce the cost of distance (Cohen et al., 2002; Cohen-Blankshtain & Nijkamp, 2004), enable global interactions by facilitating global economic activity (Malecki & Wei, 2009) and finally support the emergence of a world cities network. As Derudder (2006, p. 2029) emphasizes, “in a networked context, important cities derive their status from what flows between them rather than from what remains fixed within them” (Allen, 1999; Amin & Graham, 1999; Castells, 2001). Moreover, Smith and Timberlake (2002, p. 139) identify world cities as the “spatial articulations of the global flows that constitute the world economy” and Rimmer (1998, p. 439) “as junctions in flows of goods, information and people rather than as fixed locations for the production of goods and services” (Tranos, 2011b). Although geography still matters and cities retained, if not increased, their importance in the frame of the digital economy, what has changed is the importance of global urban interdependencies, the existence of which is, to a great extend, owing to ICTs and the derived socio-economic paradigm.

3. Examples of ‘digital’ urban research

Given the importance of the above, the emerging question is how urban and regional analysis and spatial sciences in general can respond to the digital economy and the derived socio-economic changes. As briefly discussed in the introduction section, two paths can be identified. Firstly, digital phenomena have geographic representations. For instance, despite what an average Internet user experiences a *placeless cyberspace*, the latter depends on *real world’s fixities*, which are found on cyberplace (Kitchin, 1998a, 1998b; for a discussion about the spatiality of cyberplace and cyberspace see also Devriendt et al., 2008). Secondly, traditional spatial phenomena can be better analyzed with the use of digital data. Owing to the extensive penetration of ICTs, a great part of human actions and interactions is channelled through digital infrastructure. For instance, commuting is heavily based nowadays in electronic ticketing and communications are handled by various digital providers such as mobile phone carriers and ISPs. This section provides some examples of research along these lines. Although the list is not exhaustive, it reflects the urban analysis’ responses to the digital economy.

3.1 Digital phenomena with spatial reflections

Firstly, using the analysis conducted by Tranos and Gillespie, the Internet physical infrastructure is analyzed from a relational urban geography perspective (Tranos & Gillespie, 2011). Using the highest tier of the Internet infrastructure, identified as the Internet backbone network, the cited paper analyses how European cities are (inter)connected via this infrastructural network. Using methods derived from the network analysis domain, such as different centrality measures, which are then summarized with cluster analysis, this paper discusses the different urban connectivities. The outcome of this analysis is not just another urban hierarchy, but rather an understanding of the new roles cities perform in the digital economy. While cities such as London, Paris, Amsterdam and Frankfurt form the *golden diamond* of the European Internet – with London being always the dominant node, cities such as Vienna, Milan, Budapest, Athens, Lisbon and Palermo have distinctive roles either as hub cities or as gateways to other continents.

The emerging question is if and how cities can take advantage of such infrastructure. From a geographic perspective, we know that the capacity of the digital infrastructure can affect local economic activity (Greenstein, 2004). From an economic perspective, it is known that at the macro (state) and micro (firm) level, the Internet improves productivity due to its General Purpose Technology nature. It is a generic technology, which was gradually developed, but once it reached a specific threshold – privatization in this case – was radically expanded across the economy with a huge variety of different applications, creating spillovers which enable the emergence of the digital economy (Tranos, 2011b; Lipsey et al., 2005). Such spillovers represent productivity increases in downstream sectors (Helpman, 1998; Malecki, 2002) which can result in economic growth and development. However, for the above to be materialised, physical digital infrastructure is necessary such as the physical infrastructural layer of the Internet.

Nonetheless, the research community knows little yet about the impact that such infrastructure generates on the meso (urban and regional) level. After performing econometric analysis based on Granger causality tests and panel data, the positive and significant impact of digital infrastructure on regional economic development can be verified (Tranos, forthcoming). However, the latter mostly applies to northern European regions, which are characterized by the necessary *absorptive* capacity to take advantage of such infrastructure. This capacity is related with the sophistication of national and local economies. Just like other traditional types of infrastructure, digital infrastructure is a necessary, but not sufficient factor for economic development in the framework of the digital economy (Gillespie & Robins, 1989; Graham, 1999; Gibbs & Tanner, 1997; Hackler, 2003).

Finally, questions emerge of how well we can understand the structure and the topology of digital infrastructure. The complex structure of this infrastructure requires methodological input from other disciplines such as complexity theory and network analysis. After applying complex network analysis methods, the structural characteristics of the Internet backbone network in Europe were revealed (see Tranos, 2011b). The analysis depicted the physical constraints affecting the structure of this complex system. Although the Internet and its physical infrastructure appear to be a-spatial, its structure and topology are characterized in reality by significant spatiality. While the golden diamond performs as the core of the European Internet, the connectivity of these cities is not high enough to support the formation of scale-free networks, which are linked in the literature with super-connected hubs. Such quantitative exercises and hard evidence improve our understanding of the nature of this infrastructure, the derived urban roles and the resilience of such systems (Tranos, 2011a).

3.2 Real world phenomena approached with digital data[1]

The second stream of empirical examples refers to the use of data from phone communications in geography, which is undergoing a second golden age: while landline phone call data was traditionally used in spatial analysis and fed spatial interaction models to understand intercity relations, nowadays the interest has moved towards data derived from mobile phone communications. Geographers and other spatial scientists have started recently utilizing this new data source to gain new insights on spatial structures, population geography human patterns and interactions at different levels of aggregation in high space-time resolution.

For example, MIT's SENSEable City Lab has examined concentrations of people in a city (Reades et al., 2009), population distribution due to non-recurrent mass events such as pop festivals (Reades et al., 2007), the use of private or public spaces by individuals (Calabrese et al., 2010) and the use of location-based services as a form of insight into complex and rapidly changing spatial phenomena (Ratti et al., 2006; Ratti et al., 2007). Human geographers such as Ahas et al. (2006) studied commuting, but also tourist patterns (Ahas et al., 2007; Ahas et al., 2008). Such data has been also used in mobility studies (Lambiotte et al., 2008; Licoppe et al., 2008) to shed light on the displacement and mobility paradigm (Sheller & Urry, 2006). In complexity and network science fields, researchers such as Barabási and his colleagues explored the statistical mechanisms governing the formation of complex networks of human communication in cellular networks. For example, the work of Song et al. (2010a; 2010b) links mobility discussions with statistic physics, while Candia et al. (2008) illustrate individual human dynamics using mobile phone records as the main instrument. Other examples in relevant research fields include Eagle et al. (2009) who analyzed spatial friendship network structures and Steenbruggen et al. (2011) in the transport and incidents management field.

The reason behind the recent flourishing of these studies is twofold. Mobile phone penetration has increased dramatically over the last decade: at the end of 2011 there were 6 billion mobile phone subscriptions and global penetration reached 87 per cent (ITU, 2011). Due to the nature of such devices and their underpinning technology, data from mobile phone usage can provide insights on various geographic questions, which otherwise would be impossible to quantitatively understand and model. In addition, it seems that we are reaching the point that such data has become available to researchers, not because privacy issues have been largely solved, but mostly because telephone carriers are interested in exploiting the huge pool of data generated by their services for reasons other than network optimization.

To facilitate the discussion on utilizing digital data to capture traditional urban phenomena, a simple example is presented here. This is an explanatory econometric model explaining the relation between urban land use types and mobile phone intensity. The value added by this approach is the fine temporal resolution of mobile phone data. Indeed, the basic input for

[1] This work is in collaboration with John Steenbruggen and Henk Scholten

this model is aggregated data for mobile phone usage at the level of the GSM (Global System for Mobile Communications) cell for the city of Amsterdam, Netherlands. In total the city of Amsterdam is covered by circa 800 GSM cells and the data is available for the period of one month in hourly intervals. This results to a very large dataset, which can provide valuable empirical insights on the temporal variation of the usage of different land use types during the course of a week (i.e. working versus non-working days) and during the course of a day (i.e. different hours of the day). The underlying assumption is that population concentration is highly correlated with mobile phone usage due to the almost universal mobile phone penetration.

In order to capture these temporal effects, three way interaction terms are introduced in model (1):

$$mob_{it} = B_1 X_i * T_t * H_t + B_2 X_i + a_1 control_i + a_0 + \varepsilon_{it} \tag{1}$$

According to this model, mobile phone activity (mob_{it}) in area *i* and time *t*, as depicted by the total volume of mobile usage known as *erlang*, is affected by a vector X_i of land use types interacting with a vector T_t, which distinguishes between working and non-working days, and a vector H_t, which introduces hour-to-hour variability. In addition, the model includes a vector of control variables $control_i$ such as the total area of the cell (*area*) and the volume of the build space (*volume*). Such a model exploits the panel data nature of the mobile phone data. Simply put, we consider the dual dimension of the dataset: space and time. In regards to the model estimation, panel data regressions have been used. In more detail, a GLS estimator is employed to estimate (1) as a random effect panel model. Most importantly, first order serial autocorrelation which can be a source of bias in our data, is addressed here with the use of the xtregar module of Stata software. Serial autocorrelation in our case reflects the dependence of the mobile phone intensity in cell *i* in time *t* on time *t-1*.

The estimation of this model is presented in Table 1. On the vertical axis we can identify the different land use types on working and non-working days and on the horizontal axis the different times of the day are presented. In overall, this regression represents the *heart-beat* of Amsterdam. For instance, we can see that the impact of traffic land use type becomes positive (green colour) earlier on working days than on non-working days. Similarly, there is a 2-3 hours difference before the impact of residential, business, recreation and nature land use types becomes positive. In addition, we can see that the magnitude of the impact is higher on working days for traffic land use and its variation during these days is also higher. The difference between working and non-working days is marginal for residential areas, but this is not the case for business areas, where the impact is more than double on working days. As these are only preliminary results, more analysis needs to be done for the recreation and nature land use types, as the magnitude of impact is higher than expected . Attention needs also to be paid to potential spatial autocorrelation issues. Nonetheless, the estimations come as no surprise as they reflect the heart-beat of Amsterdam.

INSERT TABLE 1

4. Conclusions

The digital revolution has clearly created a type of less visible digital – or cyber – infrastructure that is difficult to understand and imagine in terms of its impacts on spatial development. But in addition, it has prompted a wealth of less visible information and data flows that have a great variety of interaction impacts on human behaviour and on social as well as economic systems. Such interwoven space-time connectivity patterns embody all elements of a complex system, with dynamic changes – sometimes unforeseen - and with a myriad of actors involved. The final outcomes of these complex feed-back and feed-forward systems call for quantitative, data-instigated data analysis, using the fruit from modern complexity science. Such an analytical approach can provide the necessary tools to empirically support research focusing on the digital revolution from a spatial perspective.

To conclude, this chapter demonstrated the need for spatial sciences to focus more on the digital revolution. The plethora of new digital data – which is a direct impact of the digital revolution - calls towards an *e-regional science* (Tranos, 2011a), which will address digital phenomena from a spatial perspective and utilize digital data to approach traditional geographical questions. Such a research direction can provide useful feedback to policy makers and enable them to include 'digital' elements in the local policy agenda. Although ICTs appear to be a black box for urban and regional planners, hard evidences summarized here suggest that digital infrastructure and the digital revolution in general have a place in a regional development policy framework.

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Table 1: Amsterdam's heart-beat using mobile phone data

hours		**00:00**	**01:00**	**02:00**	**03:00**	**04:00**	**05:00**	**06:00**	**07:00**	**08:00**	**09:00**	**10:00**	**11:00**	**12:00**
l.u. traffic	**w.d.**		-0.012	-0.02	-0.023	-0.022	-0.003	0.016	0.03	0.045	0.048	0.045	0.045	0.045
			(0.000)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***
	non-w.k.		-0.012	-0.022	-0.024	-0.021	-0.014	-0.004	0.004	0.011	0.017	0.021	0.023	0.024
			(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***
l.u. residential	**w.d.**		-0.01	-0.019	-0.026	-0.031	-0.034	-0.026	-0.01	0.002	0.008	0.011	0.012	0.012
			(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
	non-w.k.		-0.006	-0.012	-0.016	-0.02	-0.025	-0.029	-0.024	-0.013	-0.002	0.005	0.008	0.01
			(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
l.u. business	**w.d.**		-0.008	-0.015	-0.019	-0.023	-0.022	-0.009	0.011	0.025	0.032	0.036	0.037	0.038
			(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
	non-w.k.		-0.006	-0.011	-0.014	-0.017	-0.02	-0.021	-0.017	-0.008	0.001	0.007	0.012	0.014
			(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	-0.001	(0.001)***	(0.001)***	(0.001)***
l.u. recreation	**w.d.**		-0.011	-0.021	-0.028	-0.031	-0.025	-0.009	0.008	0.021	0.026	0.026	0.027	0.027
			(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***
	non-w.k.		-0.007	-0.015	-0.021	-0.027	-0.027	-0.024	-0.015	-0.004	0.006	0.012	0.016	0.017
			(0.000)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***
l.u. nature	**w.d.**		-0.035	-0.067	-0.084	-0.088	-0.063	-0.007	0.045	0.077	0.086	0.088	0.089	0.088
			(0.002)***	(0.003)***	(0.003)***	(0.004)***	(0.004)***	(0.004)*	(0.004)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***
	non-w.k.		-0.021	-0.04	-0.059	-0.07	-0.085	-0.077	-0.038	-0.003	0.025	0.047	0.054	0.054
		BASE	(0.003)***	(0.004)***	(0.005)***	(0.005)***	(0.005)***	(0.005)***	(0.005)***	-0.005	(0.005)***	(0.006)***	(0.006)***	(0.006)***

hours		**13:00**	**14:00**	**15:00**	**16:00**	**17:00**	**18:00**	**19:00**	**20:00**	**21:00**	**22:00**	**23:00**	**l.u.**
l.u. traffic	**w.d.**	0.045	0.045	0.046	0.048	0.048	0.044	0.036	0.03	0.026	0.02	0.012	-0.011
		(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.003)***
	non-w.k.	0.023	0.022	0.021	0.02	0.02	0.02	0.02	0.02	0.016	0.012	0.005	-0.009
		(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.003)***
l.u. residential	**w.d.**	0.012	0.012	0.012	0.013	0.014	0.014	0.013	0.014	0.015	0.013	0.008	0.009

		(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.002)***
	non-w.k.	0.009	0.009	0.008	0.008	0.008	0.008	0.008	0.009	0.009	0.007	0.003	0.01
		(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.002)***
l.u. business	**w.d.**	0.038	0.039	0.038	0.037	0.035	0.03	0.024	0.021	0.019	0.015	0.01	-0.02
		(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.002)***
	non-w.k.	0.015	0.015	0.015	0.015	0.014	0.011	0.01	0.009	0.009	0.006	0.003	-0.016
		(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.002)***
l.u. recreation	**w.d.**	0.027	0.028	0.029	0.031	0.032	0.03	0.024	0.022	0.021	0.018	0.011	-0.008
		(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.002)***
	non-w.k.	0.017	0.017	0.016	0.016	0.016	0.014	0.012	0.013	0.013	0.01	0.006	-0.005
		(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.002)**
l.u. nature	**w.d.**	0.088	0.088	0.089	0.091	0.092	0.084	0.071	0.07	0.068	0.056	0.035	-0.003
		(0.004)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***	-0.013
	non-w.k.	0.057	0.055	0.052	0.05	0.051	0.047	0.045	0.051	0.049	0.038	0.02	-0.001
		(0.006)***	(0.006)***	(0.006)***	(0.006)***	(0.006)***	(0.006)***	(0.006)***	(0.006)***	(0.006)***	(0.006)***	(0.006)***	-0.013
		area	0	volume	0	Constant	-0.477	Observations		371981			
			(0.000)***		(0.000)***		(0.153)***	Number of cells		520			

Standard errors in parentheses; ** significant at 5%; *** significant at 1%; l.u. = land use; w.d. = working days

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